SUMMARY
TECHNICAL REPORT
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AD

AN EVALUATION OF SELECTED ADVANCED HIGH PRODUCTION FEEDING SYSTEMS

by

Robert S. Smith
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February 1972

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Operations Research and Systems
Analysis Office

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This report covers the results and findings of an evaluation of three types of high production feeding system concepts which represent five major categories of high production feeding operations.

Meal cost, system effectiveness and advantages and shortcomings of these systems are discussed.

It is concluded that where there are a large number of dining facilities to be serviced, the use of central preparation appears to be the least costly system while also offering uniformly high quality and variety food products.

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FOREWORD

In 1969 the DOD Facilities and Equipment Planning Board accomplished an on-site survey of military garrison feeding facilities in the United States. As a result of this survey, this Board created, with DOD approval, a project to study, define, and then implement a new, modern feeding system at Fort Lewis, Washington. As documented in the approval for this project, the objectives were to improve performance and reduce costs. This new system could then serve as a model for all military services.

In 1970 the newly created DOD Research and Development Food Program was established at NLABS. Included within this program was an increased emphasis on garrison feeding systems and a new requirement to study military feeding from a total systems concept. This new requirement was assigned to the Operations Research and Systems Analysis (OR/SA) Office at NLABS, and resulted in a rather unique, but logical merger of the R&D systems study effort with the DOD project cited above.

The OR/SA systems analysis study effort was conducted as Task 03 under Project No. 1J662713AJ45, Systems Studies in Military Feeding and was initiated in November 1970. The objective was to design a new feeding system which would increase customer satisfaction and reduce operating costs, in that order of importance.

Because the information and data which have been developed during the project are both extensive and complex, this report is only one of several reports being published concerning the overall project. It contains the results of an evaluation of advanced high production feeding systems, representative of the latest state-of-the-art concepts for mass feeding. These results have already been utilized in a 90 day feeding experiment at Fort Lewis and are currently being applied in a conceptual design of a pilot scale state-of-the-art feeding system. This pilot plant, if successful, could be a prototype for large military installations worldwide.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This report covers the results and findings of an evaluation of three types of advanced high production feeding systems concepts which represented five major categories of high production feeding operations.

Meal cost, system effectiveness and the advantages and shortcomings of these systems are discussed.

It is concluded that where there are a large number of dining facilities to be serviced, the use of central preparation appears to be the least costly system while also offering uniformly high quality and variety food products.

INTRODUCTION

An advanced feeding system can be considered as an integrated program of personnel and equipment for the procurement, storage, preparation, distribution and service of foods and related sanitary functions.[5] It represents a sophisticated and highly complex systems-oriented operation in which high quality foods are prepared in an efficient, economical manner using up-to-date processing equipment. Food products can either be prepared and served on-site or prepared, packaged, distributed to a serving facility and finished for consumption at the serving facility in equipment especially designed for this purpose. The successful operation is one in which both customer satisfaction and cost savings are achieved.

During the past ten years, designers of food service facilities have placed an increased emphasis on the systems approach in their design of new food service facilities.[1] Modern feeding systems are being designed to capitalize on the latest techniques in food technology and automation. This has resulted in advancing from full preparation and service at the feeding site to the application of mass production techniques to create varying degrees of centralization.[5] Since volume influences operating cost, modern mass feeding concepts have tended toward larger capacity dining facilities which have resulted in labor savings, but often at the sacrifice of customer convenience.

The high cost of labor is perhaps the single most overriding problem facing food service managers today.[3] This problem is attributed to a combination of the high wages paid in recent years (e.g., airline scullery operators receive a starting salary of $3.70 per hour) and the decreasing availability of qualified food service personnel. This is especially important in view of the fact that the industry has been averaging a growth of 12% annually which has far surpassed the availability of qualified personnel.[4] The food service industry has responded to this labor problem by utilizing new types of equipment, pre-prepared and pre-cooked frozen foods, modern management techniques, computer technology and innovation.

The Department of Defense (DOD), like the food service industry, has also experienced significant increases in the cost of labor over the past few years. For instance, the E-5 sergeant of 1962 cost DOD $3700 annually, compared to $6837 for his 1971 counterpart. These increased labor costs are particularly significant in view of the fact that DOD has the largest feeding system in the United States, serving over one billion dollars worth of food (raw food cost) during the fiscal year 1971.

Since the end result of the project (Systems Studies in Military Feeding) would be a new system for large military installations, it was considered essential to evaluate the latest state-of-the-art feeding systems currently operational in the United States. The information and data obtained would then be used to determine which type of feeding system could best meet DOD's needs to increase customer satisfaction and decrease operating costs.

OBJECTIVE

The primary objective of this evaluation was to conduct on-site surveys of *representative types* of advanced high production feeding systems to determine their overall performance capabilities, advantages, and shortcomings. To achieve this objective the following information and data were obtained and/or computed for the feeding systems investigated:

- Number of Meals Served per Day
- Number of Operating Personnel
- System Effectiveness (meal/man-hour)
- Average Total Cost per Meal

SYSTEMS SELECTION AND EVALUATION

Evaluation Criteria and Methodology

A substantial amount of published material exists concerning advanced high production feeding systems from which a representative cross section was identified.[7] A plan was devised to collect information and data from these systems and necessary arrangements were then made for actual on-site observations which were considered essential to establish a common baseline for comparing the relative performance of the various systems. A total of 12 visits were made to obtain information and data which would be used to draw conclusions concerning the overall performance of the feeding systems studied.

The representative types of systems studied embodied the concepts listed below:

- Food prepared on-site in large consolidated dining halls
- Food prepared in a central facility and served in satellite dining halls
- Food purchased in a pre-prepared or pre-cooked frozen condition from a vendor and finished at the dining facility

These concepts are considered to be the most advanced volume feeding concepts being utilized by a number of large system operators in the United States, including:

- Military (serviceman)
- Industrial (employee)
- Commercial (general public)
- College (students)
- Airline (passengers)

Other mass feeding operations such as the primary and secondary schools and hospitals are not included in this report although they were also surveyed. The reason for this was that the type of meals and service they offer their customers is not comparable to the other operations surveyed and, therefore, would not provide a valid comparison. For these same reasons, commercial restaurants providing waitress service are not included.

Number of meals fed per day, system effectiveness and meal cost data are given in Table I to compare the five categories of operations which were evaluated.

These data indicate an average for each of the various systems listed. It is important to note that these figures do not necessarily reflect the maximum capacities of these systems.

System Effectiveness is defined as follows:

$$E = \frac{M}{P_1 H_1 + P_2 H_2}$$

where:

E	=	system effectiveness
M	=	number of meals
P_1	=	number of full-time personnel
H_1	=	hours worked by full-time personnel
P_2	=	number of part-time personnel
H_2	=	hours worked by part-time personnel

TABLE I

PERFORMANCE DATA OF REPRESENTATIVE HIGH PRODUCTION FEEDING SYSTEMS

Feeding System Concept	Number of Meals Fed per Day	System Effectiveness (meal/man-hour)	Average Total Cost per Meal
Military			
Present Fort Lewis System[1]	50,000	3.1	1.29
Consolidated with on-site preparation	11,000 to 13,000	5.6 to 8.5	1.20[2] to 1.05
Central preparation with satellite dining halls	2,100	2.2	1.65[2]
Industrial			
Central preparation with satellite dining halls	18,000	6.0	1.06
Commercial			
Central preparation with satellite dining halls	over 100,000	not available	1.53
College			
Vendor supplied frozen foods pre-prepared	30,000	9.5	1.15
Airline			
Central preparation with satellite feeding (aircraft)	1,800 to 2,300	3.9 to 4.9	1.80 (coach) to 4.80 (first class)

[1] Shown for comparison purposes.
[2] Estimated cost.

It should be pointed out that the number of operating personnel are not shown in Table I, however, these figures are reflected in the systems effectiveness calculations. The system effectiveness for three of the systems shown should be discussed further. The 2.2 meals per man-hour figure for the military central preparation with satellite feeding system is quite good when the small number of customers (8 to 20) served at the feeding site is considered. The 9.5 meals per man hour figure for the college system reflects the labor already put into the food products by the vendor. The 3.9 and 4.9 meals per man-hour figure for the airline feeding system must be considered in the light of the uniqueness of feeding in aircraft. This is one of the more difficult types of food service. If the serving time of the stewardesses is excluded, the figures become 5.5 and 7.0 meals per man-hour, respectively.

System effectiveness figures for the commercial operations observed could not be obtained. Much of the data needed is considered proprietary information. It was decided not to present material available in the literature since the basis for the calculations were not known. System effectiveness figures from the industry and college feeding system were considered sufficient to compare central preparation with and without vendor supplied pre-cooked foods.

Average total cost per meal figures include food, labor and all operating costs (utilities, supplies, etc.). It should be noted that capital costs have not been included. Meal costs shown for the military, college and airline operations reflect the average cost for breakfast, dinner and supper. The cost shown for the industrial operation is primarily for dinner and the cost for the commercial operation is for dinner and supper. Data shown for the present feeding system at Fort Lewis[6] is shown for comparison purposes only.

Military Feeding Systems

The two most advanced feeding systems operated by the United States military services today are based on the concept of preparing food on-site in large consolidated dining halls; and centrally preparing food and serving in satellite dining halls. No operational military systems totally depend on vendor supplied pre-prepared or pre-cooked frozen foods although the use of frozen vegetables and pre-prepared ingredients is commonplace.

Large Consolidated Feeding

The first type of military feeding system observed was one based on the concept of large consolidated dining facilities. Such facilities normally have a capacity of 1,000

to 4,000 customers, and all food preparation is performed on-site in the dining facility kitchen. Some consolidated facilities use one large seating area, but most divide the seating area into several rooms each seating 150 to 250. Usually the high capacity is based upon several customer seatings per meal period.

One of the military consolidated dining facilities observed, prepared and served an average of 4,100 meals in approximately 80 minutes with 170 food service personnel. This particular operation had been recently modernized. Installation of continuous cooking equipment and mechanization of the food holding and carrying equipment greatly improved the efficiency of the operation. The modernization reduced pre-service preparation time from 120 to 45 minutes and allowed a 25% savings in manpower. Another consolidated facility observed which did not have continuous processing equipment prepared an average of 4,000 meals in 90 minutes with 258 food service personnel.

Central Preparation/Satellite Feeding

The second type of military feeding system observed was one based on the concept of central preparation with satellite feeding at small remote dining facilities. In this system food is prepared in one centrally located facility, packaged in individual aluminum containers, and then transported in the frozen state to satellite dining halls which are located at distances ranging from 25 to several hundred miles from the central preparation facility. This system was designed in response to a unique requirement for feeding small groups of 8 to 20 military personnel stationed in remote areas. It is the only truly centralized preparation feeding system currently operated by the military, although others are in various stages of development.

This particular system was producing approximately 2,100 meals per day at the time of this evaluation. A total of 202 food service personnel were required, 52 in the central preparation facility and 150 at 70 feeding sites. System effectiveness increased by over 50% when compared with the conventional methods of on-site preparation previously utilized. In addition to the increased system effectiveness, a 15% increase in raw food yield has been realized.

Food items were packaged in individual servings in aluminum foil containers and were heated directly from the frozen state using conventional ovens. After heating, the food (except for desserts) was transferred to plates to remove the "TV dinner" connotation of eating directly from the aluminum container. The use of an individual serving package for each meal component also allows a great many meal combinations with a reduced number of food items.

The features unique to this system from a military standpoint were the use of a walk-in type blast freezer and a specially designed crimping machine which automated the lidding portion of the packaging operation.

Industrial Feeding System

Large manufacturers have become extremely active in the modernization of the systems which feed their employees, because meals are a part of their fringe benefit package. Also, the length of the meal period has a significant impact on production schedules. Therefore, it is to the company's advantage to provide in-plant feeding to shorten the meal period. The operation of their feeding system, therefore, not only affects employee morale but also has an effect on company profits.

Industrial feeding in the United States today reflects some of the most modern mass feeding concepts. One large manufacturer is operating a system which is especially noteworthy. This system is based on the concept of central preparation with satellite dining facilities and is primarily serving meals during the noon hour. A total of 13 satellite cafeterias were located at distances from 2 to 35 miles from the central preparation facility. The largest cafeteria served 1,700 employees in a 2 hour period with 35 food service workers. Production in the central preparation facility averaged 18,000 meals per day which was accomplished with a total of 27 full-time food service personnel. Approximately 50% of the entrees were centrally prepared and were transported to the satellite cafeterias in the chilled condition (40°F). The remainder of the entrees, i.e., steaks, chops, roasts and deep fat fried items were prepared on-site in the cafeterias since it either decreased the on-site preparation time or improved product quality. A small number of the products were centrally pre-prepared and frozen to maintain a constant production level. These were used as a reserve supply in the satellite facilities.

An important aspect of this central preparation facility is the ingredient room which was a distinctly separate and rigidly controlled operation for the preparation and weighing of all vegetables, meat and dry ingredients. This operation was found essential to maintain high quality products and formulations in accord with the recipes. Centrally prepared foods were packaged in large containers such as half gallon wax coated paperboard cartons and full size stainless steel steam table pans. These products were, for the most part, prepared one day prior to use and delivered in stainless steel, closed transporters which were delivered to the satellite cafeterias by refrigerated vehicles on a daily basis.

This system has yielded some significant improvements in the area of total meal cost. An overall 8% reduction of the combined food and labor costs have been realized as compared to the previous system of on-site preparation in large cafeterias.

College Feeding System

The college feeding system evaluated was based on the concept of vendor supplied pre-prepared and pre-cooked frozen foods. The system consisted of five dining rooms, each seating 900 students. However, one dining room having the largest kitchen was preparing salads, several bakery items as well as some entrees. An average of approximately 30,000 meals were being served daily which required 377 full-time and 102 part-time personnel. For the weekday lunch and dinner meals, the student had a choice of two or three entrees, vegetables, salads, and desserts, and a snack bar line.

It is significant to note that several entrees such as macaroni and cheese, meat loaf, and chicken a la king were prepared centrally rather than purchased in a pre-prepared form. The main reason was that these particular items, when supplied in the frozen state by vendor, were of unacceptable quality.

Another significant point is that it has been found necessary to closely monitor frozen entrees supplied by vendors to assure product uniformity; major variations in quality have been experienced, even from well-known and highly regarded vendors. Since the cost of testing each shipment would be prohibitive, sampling by an acceptance group and close attention to customer complaints are relied upon to control quality. This group also devotes a large effort to the evaluation of new products and new vendors.

The major cause of this quality control problem stems from the lack of standardized quantitative methodology for measuring product quality. Until such time as rapid and low cost quality assurance methods are developed, detailed specifications for these products cannot contain adequate quality assurance provisions and will therefore be inadequate procurement instruments.

Equipment requirements for this system are considerably different than the other systems observed. Steam kettles and large vegetable holding areas are not required, whereas, ovens, holding cabinets, high pressure steamers, and freezers are the most essential items

of equipment. Additional significant aspects of this system which should be cited are the use of the computer for cost and inventory control and the thawing of the frozen foods at refrigeration temperatures overnight. Thawing of food decreases the time required to heat the product and lessens the possibility of burning the food surfaces and edges.

Airline Feeding Systems

Airlines generally have a requirement to feed passengers during meal hours on flights which last longer than one hour. The airlines have responded to this requirement by either operating their own feeding system or contracting with a commercial airline caterer for the preparation and assembly of their foods. Two feeding system concepts prevail in the airlines today; central preparation and assembly of fresh foods or central assembly of foods which have been purchased from a vendor in the pre-prepared or pre-cooded frozen state. Regardless of whether the food is freshly prepared centrally or vendor supplied, pre-proportioning and tray assembly is accomplished prior to loading the food onto the aircraft. It should be pointed out that the vendor supplied products are especially developed for the airlines and are not products available on the commercial market.

One of the airlines which depended heavily upon vendor supplied pre-cooked frozen foods has experienced many of the same food quality problems which are cited in the college feeding section of the report (see page 10). The inability to precisely quantify food quality appears to be a major element of this problem. As a result the airline must depend almost entirely on customer feedback for an assessment of food quality.

The state of the food (i.e., hot, chilled, or frozen) leaving the central processing facility generally depends upon the length of the flight. Some airlines use all three states. Frequently, those using a frozen system heat the food before loading it into the aircraft for flights of short duration.

In one of the central preparation facilities which was observed, 2,300 meals per day were served on 21 flights. A total of 72 full-time personnel were required. In the central facility which was using vendor supplied pre-cooked frozen foods, 1,800 meals per day were served on 14 flights. A total of 44 full-time personnel were required. The above figures represent airline catering operations at one large international airport. These operations differed by 20% in their system effectiveness.

In general, the airline food operations were too small to have continuous food processing equipment, but they did use conveyor lines for tray assembly. Small convection ovens were the primary means for heating the food on the aircraft.

The airlines also have a requirement which further distinguishes their operation from the other feeding systems which were observed, namely their central dishwashing function (scullery). Operation of a central scullery is necessary since the use of silverware, reusable plastic trays and cups, and porcelain or reusable plastic casserole dishes results in a major dishwashing requirement. It should also be mentioned that some disposable plastic glasses, salad and dessert cups are used, however, the use of disposables is restricted because of aesthetics and cost.

A severe cleaning problem is created due to the fact dirty tableware dries for several hours before washing. Because of this, airline sculleries have a large pre-soaking tank and effectively pre-wash almost everything. Dishwashers are large four or five tank flight type models that have one or two pre-wash cycles, a wash cycle, a rinse cycle, a final rinse cycle and a drying section. In addition airlines use special cart washers to clean the tranporters used to carry food and tableware to and from the aircraft.

Commercial Feeding Systems

The commercial feeding system evaluated consisted of a central preparation facility which supplied its cafeterias, and other commercial outlets which were located at distances varying from 5 to 1,000 miles from the central facility. Figure 1 shows a typical layout of a modern commercial cafeteria.[3]

This system was by far the largest operation observed having a capability of producing in excess of 100,000 meals per day. A total of 700 personnel were required to operate the central processing facility. These included management, professional, technical and production personnel. The facility had two test kitchens and a bacteriology laboratory. The central facility bore no resemblance to a kitchen. It was a highly automated manufacturing plant where over 600 different food items were produced. Personnel requirements for distribution, cafeteria and other outlet operations could not be obtained to calculate the meals per man-hour figure for Table I.

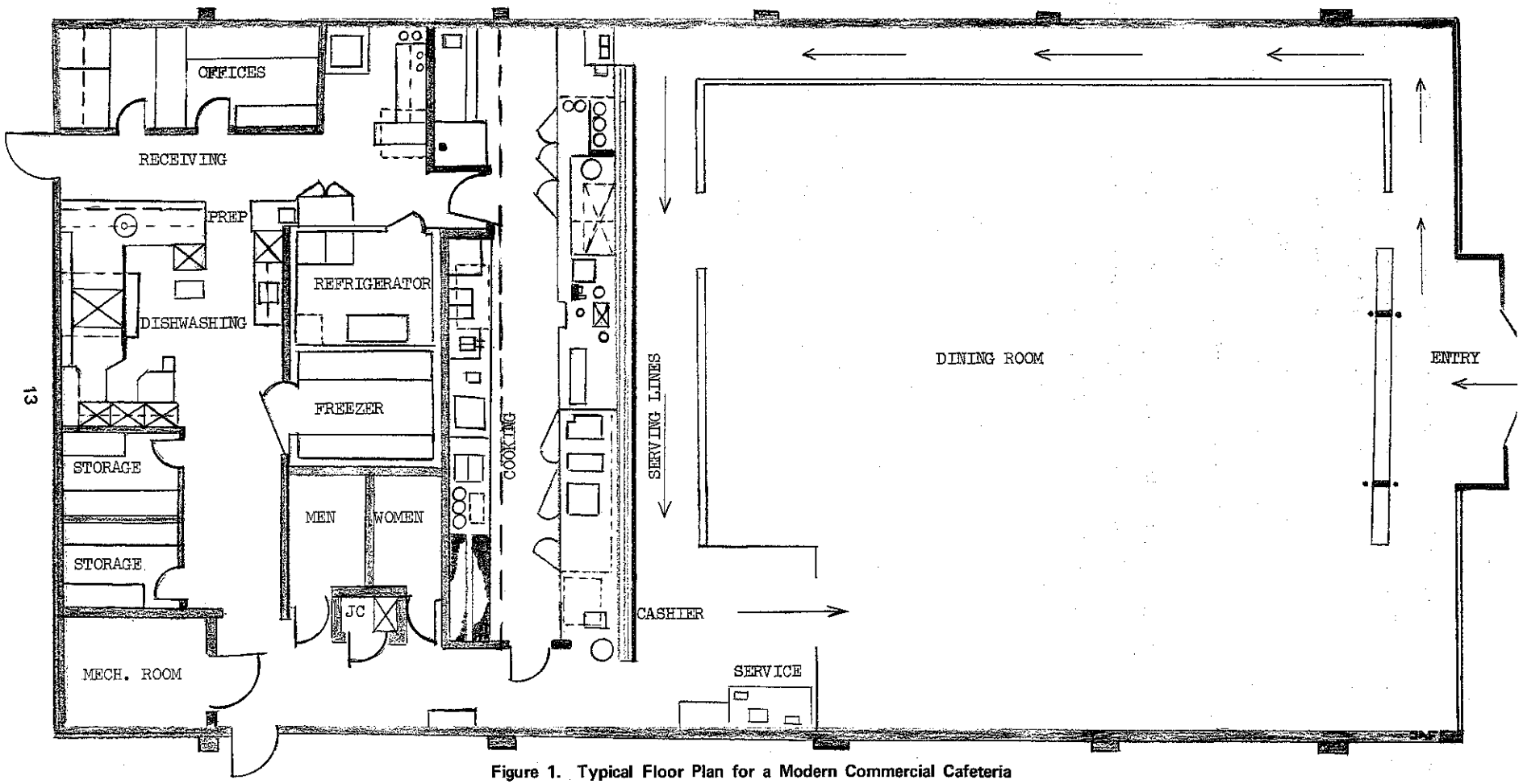

Figure 1. Typical Floor Plan for a Modern Commercial Cafeteria

The central facility depended on automated equipment for efficiency, i.e., large capacity (500 gallon) steam kettle with automatic measuring and loading of ingredients, automatic transfer of finished product and automatic filling and packaging. The packaged food was dated, placed on a rack, fast frozen in a blast freezer and packed for shipment. The working area and number of people actually cooking were relatively small considering the production capacity. As a result of the high degree of automation, the manpower requirements for the central processing facility were significantly reduced.

Food is shipped twice a week. Most items are shipped frozen to the distant locations and chilled to locations close (50-mile radius) to the manufacturing plant. Highly perishable foods that could not be frozen were prepared centrally for the commercial outlets close to the plant, but were prepared on-site at the more distant locations.

This feeding system depended heavily on a management information system for optimizing the overall operation. Orders are placed by teletype and entered into the computer. The computer then produces ingredient ordering requirements for procurement, recipes and schedules for production, and instructions for storage and shipping. In addition, the computer performs all the accounting and supplies the billing for each outlet. Along with the normal housekeeping data processing, the computer supplies a number of summary and performance reports to management on a regular basis. Utilization of the computer for these routine, but essential, tasks has improved overall efficiency and reduced manpower requirements.

Advantages and Shortcomings of Systems Concepts

Each of the system concepts evaluated had a number of advantages and shortcomings which are shown in Table II.

TABLE II

ADVANTAGES AND SHORTCOMINGS OF

HIGH PRODUCTION FEEDING SYSTEM CONCEPTS

Feeding System Concept	Advantages	Shortcomings
Large consolidated dining facilities with on-site preparation.	Decreased manpower requirements. High worker productivity. Lower total construction cost due to reduced number of facilities.	Distance customers must travel to get to dining hall. Impersonal mass feeding environment in dining facility. Difficult to control quality.
Central preparation with satellite dining facilities.	Decreased manpower requirements. High worker productivity. Uniform quality of food products. Little or no modifications required to utilize existing dining facilities. Increased yield from raw food.	High cost of building a central preparation facility. Requires some personnel with technical degrees Increased food distribution costs.
Vendor supplied pre-prepared or pre-cooked frozen	Minimum manpower requirements. High worker productivity. Reduced skill level requirements of operating personnel	Higher total meal cost than consolidated or central preparation systems. Highly variable product Extremely difficult to control product formulations. Cooks lose much of their proficiency. Restricted variety of menu items.

SUMMARY

A feeding system can be considered as an integrated program of operating personnel and equipment responsible for the procurement, storage, preparation, distribution and service of foods and beverages.

During the past ten years, an urgent need for increased worker productivity within the food service industry has resulted in designers taking a systems approach in the design of modern feeding systems, which capitalize on the use of pre-prepared foods, disposable containers and tableware, and continuous processing equipment.

The representative types of systems observed embodied three concepts: large consolidated systems with on-site preparation; central preparation with satellite dining halls; and vendor supplied pre-prepared and pre-cooked frozen foods. These three concepts are being utilized by a number of large food service operators: military to feed servicemen, industrial to feed employees, commercial to feed the general public, college to feed students, and airline to feed passengers. These operations, which were serving between 2,100 and 100,000 meals per day, were analyzed.

The consolidated systems were found to offer advantages of increased worker productivity and lower construction costs although the lack of customer convenience is a major shortcoming of this system.

The central preparation systems were found to offer the advantages of uniform product quality, increased yields from raw food, increased worker productivity, and decreased food cost. The major shortcomings found were the need for personnel with greater technical skills to assure product quality and microbiological safety plus the high capital outlay initially required to construct the central preparation facility.

The vendor supplied pre-prepared frozen foods systems were found to result in higher overall operating cost even though worker productivity is high and labor requirements are significantly reduced. Further, a significant variation in product quality was reported even with products from the same manufacturer. The lack of standardized quantitative methods to measure product quality which could be included in product specifications is considered a major element of the quality control problem.

High production feeding systems have resulted in the realization of major improvements in food preparation and processing equipment. These improvements result in great increases in worker productivity through automation and reduced preparation time.

In the area of computer technology, some of the largest feeding systems have developed management information systems to optimize their overall operation. Such operations as production scheduling, storage and shipping, and accounting are performed by the computer. Summary and performance reports are also provided to management. The advantage of computer technology in large feeding systems has been clearly demonstrated.

CONCLUSIONS

It is concluded that advanced high production feeding systems are capable of achieving a significant improvement in system effectiveness over conventional kitchen food preparation and service techniques with resultant reductions in labor cost. In feeding systems where there are a large number of dining facilities, the use of central preparation appears to provide the greatest overall reduction of total costs while simultaneously offering uniform high quality products. The one major qualifier is the need for having a sufficiently large customer population to justify the cost of constructing the central preparation facility.

It is further concluded that presently available vendor supplied pre-prepared and pre-cooked frozen foods, with the exception of vegetables, are costly, result in restricted variety and exhibit highly variable quality. In addition, the lack of standardized quality control methods which could be used in product specifications creates a serious shortcoming which would be difficult to overcome in a high production military feeding system that must depend upon competitive procurement for its food supply.

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